GEOPHYSICAL INVESTIGATIONS

ELKTON SAND, GRAVEL AND STONE SITE

CECIL COUNTY, MARYLAND

DUNN GEOSCIENCE
Albany, NY Buffalo, NY
Harrisburg, PA

3000

DUNN GEOSCIENCE CORP.

10 SOUTH 19th STREET
CAMP HILL, PENNSYLVANIA 17011
(717) 761-6710

GEOPHYSICAL INVESTIGATIONS

ELKTON SAND, GRAVEL AND STONE SITE

CECIL COUNTY, MARYLAND

Prepared for:

AEPCO, INC.
Dr. James S. Whang, P.E.
President

Prepared by:

DUNN GEOSCIENCE CORPORATION

James O. Rumbaugh, III
Hydrogeologist

Dr. Lane D. Schultz
Senior Scientist

Reviewed by:

Peter G. Robelen

Peter G. Robelen
Vice President
Mid-Atlantic Region

September 26, 1984

300001

TABLE OF CONTENTS

1.0	CONCLUSIONS AND RECOMMENDATIONS	1
2.0	INTRODUCTION AND PURPOSE	2
3.0	SCOPE AND CONDITIONS	3
4.0	TIMING AND PERSONNEL	6
5.0	SITE DESCRIPTION	7
6.0	FIELD METHODS AND DATA COLLECTION	10
6.1	EMPLOYMENT OF GEOPHYSICAL TECHNIQUES	10
6.2	ELECTROMAGNETIC (EM) TERRAIN CONDUCTIVITY SURVEY	11
6.2.1	GENERAL BACKGROUND	11
6.2.2	OPERATING PRINCIPLES	12
6.2.3	EM DATA COLLECTED	13
6.3	GALVANIC RESISTIVITY SOUNDINGS	14
6.3.1	GENERAL BACKGROUND	14
6.3.2	RESISTIVITY DATA COLLECTED	15
6.4	MAGNETOMETER SURVEY	16
6.4.1	GENERAL BACKGROUND	16
6.4.2	MAGNETIC DATA COLLECTED	17
6.4.3	DATA PROCESSING	18
7.0	DISCUSSION OF FINDINGS	18
7.1	GENERAL	18
7.2	ELECTROMAGNETIC (EM-31) TERRAIN CONDUCTIVITY SURVEY	19
7.3	MAGNETOMETER SURVEY	20
7.4	ELECTRICAL SOUNDINGS	23
7.5	OTHER CONSIDERATIONS	23

300003

FIGURES, EXHIBITS, TABLES AND APPENDICES

FIGURE 1 GEOPHYSICAL STUDY AREA

FIGURE 2 TERRAIN CONDUCTIVITY METERS

FIGURE 3 SCHEMATIC DIAGRAM OF WENNER ARRAY

FIGURE 4 MAGNETIC ANOMALY NOMOGRAM

EXHIBIT I ISO-CONDUCTIVITY CONTOUR MAP

EXHIBIT II EM-34 SURVEY SEDGE MEADOW

EXHIBIT III ISO-MAGNETIC CONTOUR MAP

EXHIBIT IV ISO-MAGNETIC PERSPECTIVE MAP

TABLE 1 GEOPHYSICAL ANOMALIES

APPENDIX A EM-34 DATA PROFILES

APPENDIX B RESISTIVITY PROFILES

APPENDIX C MAGNETIC DATA

APPENDIX D MAGNETOMETER BASE STATION PROFILE

1.0 CONCLUSIONS AND RECOMMENDATIONS

1. Six magnetic anomalies of relatively high magnitude and a seventh anomaly of lesser magnitude have been identified within the quarried portion of the geophysical study area. The relatively high magnitude anomalies range from several hundred to approximately 1600 gammas (unit of magnetic field measurement). The highest anomalies occur in the south-central site portion characterized by spoil piles. Two smaller magnitude anomalies occur in the eastern portion of the site. Magnetic anomalies are attributed to buried ferromagnetic masses. The estimated total weight of buried ferromagnetic material at the site is 45,500 pounds. Assuming that a 55 gallon drum weighs 44 pounds, this equates to 1,030 drums (if all buried ferromagnetic material consists of drums).

2. Three conductivity anomalies with closure have also been identified within the quarried portion of the geophysical study area. Two anomalies occur in the southcentral site portion and are in proximity to magnetic anomalies; coincidence of a magnetic and conductivity anomalies is striking. A third conductivity anomaly or anomalous conductivity zone occupies a larger area in the eastcentral portion and does not spatially correlate directly with a magnetic anomaly.

3. Two significant contaminant discharges are present, characterized by a orange-red viscous fluid and organic odors; the headward location of the larger occurrence was observed at the approximate intersection of survey lines

9+00 and B; the second was noted approximately 50 feet northwest of survey line G along an extrapolation of line 10+00.

4. A ground-water divide oriented northwest-southeast and bisecting the quarry portion of the geophysical study area is inferred from the terrain conductivity data.

5. Ferruginous concretionary structures observed in outcrop and within spoil pile materials suggest the Patapsco-Arundel formational contact has been exposed by quarrying.

6. Potential buried metallic masses and ground-water contaminant plumes have been identified.

7. Direct stratigraphic information of the site geologic formations from exploratory bore holes is required to determine the presence and elevation of "ironstone" concretionary layers and the continuity of clay layers. This data is necessary to prescribe optimum drilling and sampling procedures to further investigate the extent, depth and quantitative aspects of potential soil and ground-water contamination. The risk of exploratory activities encountering buried drums and containerized waste materials can be minimized by siting bore holes and trenches on the basis of the available geophysical data.

2.0 INTRODUCTION AND PURPOSE

This report presents the techniques, data and findings of the geophysical investigations completed at the Elkton Sand, Gravel and Stone site in Cecil County, Maryland. The investigation was planned in conformance with the study objectives to evaluate the existence and extent of buried ferromagnetic objects on site; to locate potential

DRAFT

contaminant plumes in the ground-water system; and to determine the presence and continuity of clay layers on and in the site vicinity. In addition these findings will assist as a rational basis in locating exploration trenches and bore holes, soil and ground-water sampling locations and monitoring wells as deemed necessary in the continuance of on-site remedial actions.

The primary methods of investigation involved the use of various geophysical techniques including electromagnetic (EM) terrain conductivity, galvanic resistivity and magnetometer surveying. Data collected with the non-destructive geophysical techniques were supplemented by field observations noted during performance of the required work.

The purpose of the investigation, therefore, was to define subsurface conditions and to determine the distribution of potential contaminant source locations to the greatest extent possible within an area of approximately 10 acres designated by AEPCO, Inc.

3.0 SCOPE AND CONDITIONS

The scope of data collection requiring field work as outlined in the proposal of July 9, 1984 included completion of the following elements:

1. Gridded survey employing a proton precession magnetomer over the suspected drum or containerized waste areas identified by AEPCO Inc.
2. EM-31 terrain conductivity techniques to establish contrasts in conductivity (inverse of resistivity) of subsurface materials to a depth of approximately 18 feet throughout the study area also on a grid basis.

DRAFT

3. EM-34 terrain conductivity to define contrasts, vertically, in conductivity soundings of subsurface materials to depths up to approximately 100 feet at selected stations and a gridded portion of the site, essentially the Sedge Meadow.

4. Conventional galvanic electrical resistivity soundings of subsurface materials at variable depth up to approximately 60 to 100 feet for selected stations.

Additional EM-31 terrain conductivity measurements were obtained along four parallel traverses, each approximately 440 feet long, on 50-foot centers in a portion of the site, formerly quarried and located west of the Sedge Meadow. This work was accomplished at the request of AEPCO, Inc. project personnel to investigate a suspect contaminant seepage source area.

Calibration control for the magnetometer survey was provided by employing a second proton precession magnetometer at a base station where readings were recorded at 20 second intervals. This procedure enabled diurnal variation corrections to be performed on data collected throughout the designated study area. Each magnetometer was tuned in accordance with standard operational procedures to insure reception of optimum signal strength. In addition, random stations were reoccupied throughout the magnetometer survey to test data reproducibility.

Lacking stratigraphic control provided by exploratory borings, calibration for the electrical techniques (conductivity and resistivity) was largely accomplished by observing outcrop locations and material types and projecting their continuity beneath stations designated for vertical soundings. Measurement of several monitoring wells completed during previous on-site studies revealed very erratic

DRAFT

water table elevations attributable to either perched conditions due to possibly discontinuous clay lenses occurring at variable stratigraphic intervals, or obstructing materials lodged within the monitoring wells precluding their hydrostatic response to the shallow, unconfined ground-water regime. It was also noted that site materials containing quantities of clay reworked as a consequence of quarry operations caused very localized ponding at varying ground surface elevations.

Geologic information provided in the AEPCO Inc. request for proposal, some of which was reproduced from the RAMP report (NUS, 1983) and site topographic maps provided by AEPCO Inc. served as information sources for assisting interpretation of the geophysical data sets.

Grid layout, staking on 100-foot centers and base maps were provided by AEPCO, Inc.

All field activities were conducted under a Health and Safety Program outlined in the AEPCO Inc. request for proposal requiring Level C personnel protection equipment and procedures. Dr. James S. Whang of AEPCO conducted a health and safety orientation program for the Dunn Geoscience Corporation field team including review of notification and decontamination procedures and contingency plans prior to their initiation of on-site work. Baseline health certification physical examinations and laboratory analyses for each field team member were planned and evaluated by Dr. Earl S. Moyer of Harrisburg, Pennsylvania during the week preceding initiation of field work.

4.0 TIMING AND PERSONNEL

A proposal to perform the geophysical investigations within the identified site portions was submitted on July 9, 1984 to Dr. James S. Whang, P.E., President of AEPCO, Inc. Notification, dated August 16, 1984, advising Dunn Geoscience Corporation of its selection to perform the work, was received August 17, 1984. Following coordinating discussions between Dr. Whang and Dunn project personnel, mobilization activities and health certification examinations ensued.

Geophysical field work at the site was performed by a Dunn Geoscience Corporation team consisting of Messrs., John W. Purvis, Geologic Technician, James O. Rumbaugh, III, Hydrogeologist and Dr. Lane D. Schultz, Senior Scientist.

EM-31 terrain conductivity and magnetometer surveying was performed on September 6-7 by the Dunn team. On the basis of identified conductivity and magnetic anomalies, stations were selected for electrical resistivity soundings conducted on September 8. Additional work consisting of conductivity soundings circumscribing the entire geophysical study area and gridded stations within the Sedge Meadow portion of the site was completed on September 11.

The report was written by Mr. Rumbaugh and Dr. Schultz and reviewed by Mr. Peter G. Robelen, Vice President, Mid-Atlantic Region, Dunn Geoscience Corporation. Messrs., Purvis and Rumbaugh prepared the graphics. Mr. Rumbaugh coordinated the preparation of geophysical data input for computer analysis; in-house programs as well as those available at Rensselaer Polytechnic Institute in Troy, New York, through a time sharing agreement, were utilized in reducing and processing the geophysical data.

5.0 SITE DESCRIPTION

The project site, referred to as the Elkton Sand, Gravel and Stone site, Cecil County, Maryland, is located on the Atlantic Coastal Plain province; the 10-acre geophysical study area is centered approximately 2600 feet N25W from the convergence of U.S. Highway 40 and Ephrata Lane (see Figure 1). The site is readily accessible from Ephrata Lane.

One residence, a farm house, and several ancillary buildings are located on the west side of Ephrata Lane approximately 700 feet from U.S. Highway 40. The primary land utilization of this property is grazing. Surface runoff is oriented essentially west to east and presumably represents the flow direction of the shallow, unconfined ground-water regime. Domestic water supply and quality information is unknown.

Other conspicuous cultural features within the site environs include the abandoned quarry depressions, reworked overburden and attendant haul roads. There are several vertical exposures of the geologic formation(s) immediately underlying the site as a consequence of the quarrying operations. One conspicuous feature is an antenna tower, located approximately 1500 feet north northeast of the site; this tower is readily observed from most portions of the geophysical study area.

Relief within the geophysical study area is characteristically uneven owing to the quarry excavations, spoil piles and reworked sediments. The highest surveyed elevation in proximity to the site is 188.5 feet above mean sea level. This occurs at the summit of an unmined knob located along the northern boundary. The lowest elevation is approximately 117.5 feet at the southwest corner of the

Sedge Meadow. Generally, elevation increases along a west to east direction but is locally disrupted by closed and open depressions having less than 15 feet of relief.

Surface drainage is directed in a southerly route, more southeasterly in the eastern portion and more southwesterly in the western portion. Ponding at variable elevations was evident in many of the depressions although at the time of the geophysical investigations, most depressions were drained. Minor rill erosion was observed on the gentle south-facing sparsely vegetated slope below the lower haul road.

Depressed water table conditions precluded direct identification of numerous seepages although the Sedge Meadow would appear to be one such area on an intermittent basis. In fact, substantial leachate discharges were noted in proximity to the northwest and southeast boundaries of the Sedge Meadow. Another suspected seepage zone was identified at the southeast study area boundary; at the time of observation this area was dry. In general, the shallow unconfined water table appears to be coincident at a lower elevation with surface topography.

Presumably, most of the sand and gravel reserves have been excavated and, hence, further quarrying operations were undoubtedly judged by the owner/operator to be uneconomic. Several of the excavated depressions within and adjacent to the geophysical study area as well as the quarried area west of the Sedge Meadow served by the lower haul road are underlain by fine-grained materials, predominantly clay. Thus, the on-site sand and gravel deposit

300012

occurrences are limited vertically as well as laterally. The minimum depth of quarry operations appears to have been on the order of 15 to 20 feet and the maximum depth is unknown.

According to RAMP information cited from published sources the site is immediately underlain by the Patapsco Formation. This Lower Cretaceous unconsolidated formation, reportedly, consists of interlayered coarse and fine-grained sediments; the gravel occurs as lenses in sand strata. The Arundel Formation underlying the Patapsco, is composed mainly of red and brown clay and layers of concretionary masses of sandstone cemented with iron oxides or carbonate and geodes and nodules of iron carbonate and limonitic composition. Both units belong to the Potomac Group.

Clearly the occurrence of lenticulated gravel deposits quarried on-site coupled with the termination of quarrying operations at the elevation of fine-grained strata, predominantly clay, are indicative of the Patapsco Formation. However, considerable concretionary masses of variable thickness, exceeding one foot, were noted in spoil pile refuse. At least one concretionary lense was observed in a residual knob of unmined sediment. These concretionary masses are relatively well indurated consisting of medium-grained sand cemented with ferruginous materials and variably coated with iron and manganese oxides. On this basis it is possible that the Patapsco-Arundel formational contact occurs at a relatively shallow depth beneath the site having been occasionally exposed during quarry operations. Alternatively the contact between the two units may be gradational, exhibiting characteristics of both geologic formations, such that the concretionary occurrences are in the lower and/or gradational interval of the Patapsco Formation. The hydrogeologic significance of this observation is substantial and will be discussed in the context of section 7.0, DISCUSSION OF FINDINGS.

6.0 FIELD METHODS AND DATA COLLECTION

6.1 Employment of Geophysical Techniques

A variety of non-destructive geophysical techniques has been successfully utilized for investigating subsurface conditions bearing on the hydrogeologic regime at sites where the potential for soil and ground-water contaimination is suspect. As such, the geophysical methods measure material properties which must be interpreted in context of surface and subsurface geological information. In addition many of these techniques are ideally suited for rather specific applications such as detection of ferrous materials, notably steel drums, mapping of water tables and delineation of ground-water contaminant plumes. Although each method measures a unique material property, the optimum employment of geophysics usually requires two or more techniques for comparing and contrasting the various data sets in the interpretation phase.

In the case of contaminated soil and ground-water, the interpreter notes the presence and location of anomalous values obtained from the various techniques. For the Elkton, Maryland study area the magnetometer survey was employed to detect the presence of steel drums and other metallic substances, presumably sources of potential contaminant migration. The electrical methods, conductivity and resistivity, were employed to interpret water table

300014

conditions and clay layer occurrences which would provide basic input for conceptually modeling contaminant flow and planning direct exploration and sampling.

6.2 Electromagnetic (EM) Terrain Conductivity Survey

6.2.1 General Background

Electromagnetic terrain conductivity surveying is well suited for determining the variations in earth electrical conductivity (inverse of resistivity) at selected depths over large areas. This type of survey ("profiling" in resistivity terminology) was typically a very slow, labor intensive process using standard galvanic resistivity equipment. With the advent of the Geonics EM-31 and EM-34, terrain conductivity equipment one or two men can readily collect large data sets.

EM Terrain Conductivity profiling has three main advantages over resistivity: 1) EM is faster; 2) EM requires less manpower; and 3) EM equipment is non-contacting, i.e., the equipment need not touch or penetrate earth materials. The latter characteristic allows measurementts to be made even in winter when the soil is frozen or where surface contamination may be hazardous.

Standard galvanic resistivity does have one primary advantage over EM techniques, however. The electrode separation and, hence, the depth

300015

of penetration can be varied indefinitely up to several hundred feet. Thus, detailed measurements of resistivity with depth can be made. The EM terrain conductivity equipment (EM-31 and EM-34) has fixed depths of penetration varying from 2.75 to 60 meters (in increments of 2.75, 5.5, 7.5, 15, 30, 60 meters). It is for this reason that the two techniques, galvanic resistivity and EM terrain conductivity are used in conjunction for most studies.

6.2.2 Operating Principles

Electromagnetic equipment, such as the EM-34 and EM-31, run a low frequency alternating electrical current through a transmitter coil. The alternating current sets up a primary magnetic field which induces a small amount of current flow in the earth beneath the coil. The small amount of current generates a secondary magnetic field which is sensed by a receiver coil located at a fixed distance from the transmitter. The strength of the secondary magnetic field is proportional to the conductivity of the earth.

The spacing between receiver and transmitter coils and the coil orientation determines the depth of investigation. The

EM-31 (see Figure 2A) is a one-man unit with a fixed coil separation of 3.7 meters resulting in a depth of investigation of approximately 5.6 meters (18 feet). The EM-34 (see Figure 2B) has coil separations of 10, 20, and 40 meters, resulting in depths of investigation of 15, 30, and 60 meters, respectively. The latter depth estimates are based on the vertical dipole configuration. While the horizontal dipole can be used, the vertical dipole configuration is more useful in contaminant plume mapping where the water table is several feet below the land surface.

The depths of investigation given above should only be used as guidelines for selecting the correct coil separation for a given study area. The actual conductivity reading is a weighted average of conductivity versus depth. For a more detailed discussion of apparent conductivity, see McNeill, 1980.

6.2.3 EM Data Collected

Electromagnetic terrain conductivity data were collected at the Elkton, Maryland site using the Geonics EM-31 and EM-34 (10 meter and 20 meter intercoil spacing), both in the vertical dipole configuration. The lines were labeled 0+00 through 12+00 and A through G. Any

300017

significant changes in conductivity between stations were also noted and recorded. The EM-31 data were contoured using the SURFACE II program. The contour map is shown in Exhibit I.

EM-34 readings (10 and 20 meter spacings) were taken along 8 lines at 50 to 100 foot stations. The lines included: C12+00 to G12+00; C11+00 to G11+00; C10+00 to G10+00; C9+00 to G9+00; A8+00 to G8+00; E8+00 to D0+20; D0+20 to A1+00; and A1+00 to A8+00. These lines encompass the perimeter of the geophysical study area and the entire Sedge Meadow area. Data for the Sedge Meadow were contoured and are shown in Exhibit II. The other lines are shown as profiles in Appendix A.

6.3 Galvanic Resistivity Soundings

6.3.1 General Background

Standard galvanic resistivity methods are used to determine the variation in resistivity with depth and act as a check or calibration of the EM measurements. The resistivity method is very simple in concept. A low frequency alternating current is passed through two outer steel electrodes which have been driven a few inches into the ground. The potential drop across two inner electrodes is measured and an apparent resistivity value is calculated. The exact calculation depends on the electrode configuration or array used.

The Bison 2350-B resistivity meter was used in the present investigation with the Wenner electrode array. In the Wenner array, the spacing (a-spacing) between adjacent electrodes is constant. The Lee modification to the Wenner array was also used in this study, whereby two additional measurements were made at each A spacing. A potential electrode (Po) is placed in the center of the array and resistivity is measured on the left and right sides of the array. This technique is useful in determining lateral as well as vertical changes in resistivity. The Wenner array with the Lee modification is shown schematically in Figure 3.

6.3.2 Resistivity Data Collected

A total of eleven resistivity soundings were made within the geophysical study area in addition to approximately 60 EM soundings. These two types of soundings give thorough coverage of the site. "A" spacings were varied from 2 feet to 100 feet for the resistivity soundings.

The resistivity data were analyzed using the Barnes Layer Method. Although this is a semi-empirical method, it generally gives good results at shallow depth (< 100 feet) and has the distinct advantage of being programmable on such calculators as the HP-41C. Thus data reduction was accomplished in the field.

The Barnes Layer interpretation calculates true resistivity at selected depths. The results are shown in Appendix B.

6.4 Magnetometer Survey

6.4.1 General Background

A magnetometer measures the intensity of the earth's magnetic field. Normally, the earth's magnetic field is fairly uniform over a localized area at any given time but can be disturbed by the presence of ferrous metals at or near the earth's surface. The field also changes diurnally due to sunspots and changes in the ionosphere.

The magnetometer used in the present study to locate buried drums, etc., was the EG&G Geometrics G856 Proton Precession Magnetometer. In a proton precession magnetometer, a voltage is applied to a coil surrounding a decane filled container. The magnetic field produced by the coil reorients protons in the decane. The voltage is then removed and the protons come to equilibrium again with the local magnetic field.

300020

In so doing, they generate a field by nuclear precession. The magnetometer measures this field which is proportional to the local magnetic field.

The G856 Magnetometer has a sensitivity of 0.1 gamma. The high sensitivity makes it suitable for detailed studies. The G856 also stores up to 1000 data points in an internal memory for later transfer to a computer; this greatly speeds up data processing.

6.4.2 Magnetic Data Collected

A detailed magnetometer survey was conducted in the main study area from line 1+00 to 8+00 and from line "A" through "E" on the site grid. Readings of the total magnetic field were taken at 25-foot centers throughout the area. The data were stored internally in the magnetometer for later processing. The detailed survey lasted one day.

In order to be as accurate as possible, a second G856 was set up on the site at station C9+00 to monitor diurnal changes in the magnetic field of the Earth. Readings were recorded automatically every 20 seconds for the duration of the survey (see Appendix D for data).

Before running the survey, the internal clocks of each magnetometer were synchronized and each was tuned to the local magnetic field, which was found to be approximately 55,000 gammas.

6.4.3 Data Processing

Once the survey was completed, the data from each magnetometer were transfered to a Dimension 68000 computer emulating an IBM Personal Computer. The data were processed using EG&G's Magnetic Data Processing and Interpretation Programs (technical report #9) for the IBM PC. These programs corrected for diurnal drift and plotted the magnetic profiles. The profiles are shown in Appendix C. The magnetic data were contoured using SURFACE II. The iso-magnetic contour map is shown in Exhibit III. A three dimensional perspective diagram of the magnetometer data were also drawn by Surface II. This diagram appears in Exhibit IV.

7.0 DISCUSSION OF FINDINGS

7.1 General

Based on information provided in the request for proposal it is assumed that the on-site wastes are predominately organic in nature. Odors noted during the geophysical investigation confirmed the presence of such substances. Because most organics are insulators and not notably conductive, their detection must be accomplished indirectly. Hence the decomposition of waste containers, principally metal drums, served as the optimum means of locating inorganic wastes using electrical techniques. Metallic masses can be detected directly with the magnetometer. For the Elkton site, the several identified anomalies are attributed to buried containerized wastes. Specific findings of the geophysical investigations are discussed below.

7.2 Electromagnetic (EM-31) Terrain Conductivity Survey

As shown on Exhibit I, several conductivity anomalies which represent an integration of earth materials and buried objects to an approximate depth of 18 feet are conspicuously portrayed. Two anomalies centered at coordinates B+50, 6+00 and A+50, 5+00 are located in the southcentral portion of the study area where spoil piles are located. A shallow undrained depression is in proximity to the more easterly of the two anomalies; water depth probably was on the order of one foot. Together, the anomalies are elongated along survey line B+00 with conductivity contours circumscribing both, closed to the northeast and partially open to the southwest. These relationships suggest that if the buried wastes are contained and within decomposing steel drums or other metallic containers in the shallow ground-water system, than a contaminant plume is most likely flowing to the southwest. However, flow to the south, coincident with surface topography, cannot be totally dismissed. Flow to the southwest appears to be confirmed on the basis of a significant leachate discharge. The leachate is highly ordoriferous, organically, and consists of an orange-red viscous fluid. This discharge flows southwesterly from

DRAFT

its apparent surface breakout along survey line B at 9+00. The conductivity anomalies are associated with magnetic anomalies, the latter indicative of buried metallic masses, hence contaminant sources.

Another notable conductivity anomaly is located in the eastern portion of the study area centered on survey line 3+00, D: closure of the contours surrounding this center extends approximately 250 feet in an easterly direction. The geometric portrayal of the conductivity contours attributed to this anomaly suggests easterly flow of a contaminant plume caused by decomposing metallic objects within the shallow ground-water system. As with the other anomalous area, a magnetic anomaly is spatially associated with the conductivity anomaly.

A conductivity saddle occurs between the two anomalous areas and is inferred to be a ground-water divide oriented northwest-southeast. Elsewhere throughout the study area including the Sedge Meadow and a surveyed portion of the excavated area located southwest beyond the western tributary to Mill Creek, conductivity values are relatively low and uniform. The EM-31 data set suggests little regarding the presence or continuity of clay layers beneath the site to the surveyed depth of 18 feet.

7.3 Magnetometer Survey

Seven rather discrete magnetic anomalies have been identified within the quarried portion of the geophysical study area, as shown on Exhibit III, a magnetic field contour drawing and Exhibit IV, a 3-dimensional schematic

DRAFT

expression of the magnetic data. These anomalies range in magnitude from several hundred to approximately 1600 gammas (unit of magnetic field measurement). Diurnal fluctuations, up to 27.2 gammas, do not account for the identified anomalies. Many factors contribute to the size, shape and magnitude of a magnetic anomaly, thus making quantitative interpretation difficult. These factors include the target's magnetic properties, geometry, orientation with respect to the magnetometer and other metallic objects, deterioration and permanent magnetism. Because of the many variables involved, high levels of accuracy are not normally to be expected in quantifying and evaluating the depth of a targeted anomaly. The real value of the magnetometer survey is accurately locating metallic objects.

However, estimates of buried drums based on a unit weight of 44 pounds for each identified anomaly are shown on Table 1.

TABLE 1. GEOPHYSICAL ANOMALIES

Geophysical Method	Center of Anomaly	Magnitude of Anomaly	Comments or Interpretations	Steel Drums
Magnetometer	B+40 6+00	600 gammas	4000 lbs. Iron*	90
	A+40 5+60	1000 gammas	9000 lbs. Iron	204
	A+40 4+75	1600 gammas	12000 lbs.	272
	B+50 4+25 to 4+75	800 gammas	8000 lbs.	181
	D+70 4+10	700 gammas	6000 lbs.	136
	C+25 1+40	500 gammas	4000 lbs.	90
	E 6+25	300 gammas	2500 lbs.	57
EM-31	B+50 6+00	12 mmho/m		
	A+50 5+00	12 mmho/m		
	D 3+00	10 mmho/m		

* based on many simplified assumptions and only accurate to one order of magnitude.

300027

DRAFT

The influence of concretionary structures containing limonite may be significant, thereby reducing the quantitative estimate. It is noted that the southcentral study area portion could contain over 700 steel drums, probably accurate to an order of magnitude, using semi-empirical relationships shown on Figure 4. These estimates assume the masses to be at depths of 12 to 15 feet. The depth consideration is supported by surveyed depressions within the study area interpreted to be local base grade for quarrying operations. It is emphasized that the anomalies could be caused by objects other than drums.

The correlation between magnetic and conductivity anomalies overall is impressive. For the southcentral portion, decomposing metallic sources identified by the magnetometer survey would cause ground-water to be conductive, hence confirming the contaminant plume interpretation previously discussed. A similar relationship is noted among two magnetic anomalies and one conductive zone of considerate extent in the eastern study area portion. A small magnetic anomaly located on survey line E does not demonstrate a relationship to conductivity data.

A one-for-one correlation between conductivity and magnetic anomalies was not obtained and may be attributed to station density. EM-31 data was obtained on 50-foot centers along all survey lines and magnetometer data was obtained at 25-foot centers throughout the quarried portion. Thus, it is possible that localized conductive sources occurring between survey lines were not detected.

DRAFT

7.4 Electrical Soundings

Conductivity data, obtained with the EM-34 technique and galvanic resistivity (inverse of conductivity) method, together demonstrate that conductivity initially increases with depths and than decreases. Although the data sets are somewhat equivocal, the increased conductivity at shallow depths in a range up to 35 but typically less than 20 feet is attributed to clay layers beneath all portions of the study area and not to inorganic or organic contaminants. Below this depth conductivity decreases indicating non-conductive materials. This finding is supported by the rather uniform contour pattern of the Sedge Meadow where sounding measurements were obtained on a gridded basis. Because both electrical sounding techniques integrate subsurface properties to the depth of penetration, it is not possible to infer the lateral extent of individual clay layers. Minor variations in electrical data, particularly conductivity, may be caused by surface topography.

One interesting coincidence was noted along survey line 8+00 where an increased conductivity value for the 20 meter coil separation (approximately 100 feet of depth penetration) underlies a contaminant plume in the shallow ground-water system inferred from the EM-31 data (see Appendix A, line 800).

7.5 Other Considerations

The inference of clay layers beneath the site is supported by observations noted during geophysical data collection: first, several quarried depressions terminate on

300027

fine-grained sediments; second, the leachate discharge breakouts may occur at the interface of clay layers. Lastly, the Patapsco-Arundel contact or gradational contact may occur at a relatively shallow depth.

Geophysical data and observations noted during data collection also provide input for planning direct exploration and sampling. Stratigraphic bore holes should be located in areas where geophysical anomalies, particularly magnetic, have not been identified. In this way a minimal level of risk is incurred with regard to the potential for encountering metallic objects during drilling operations. The presence of concrationary structures "ironstones", probably would preclude advancement of bore holes via augering techniques, hence it would be necessary to core through such intervals. Exploration bore holes and monitoring wells which penetrate clay layers may require seals and/or grouted casing to prevent the introduction of contamination to lower elevations beneath the clay layers.

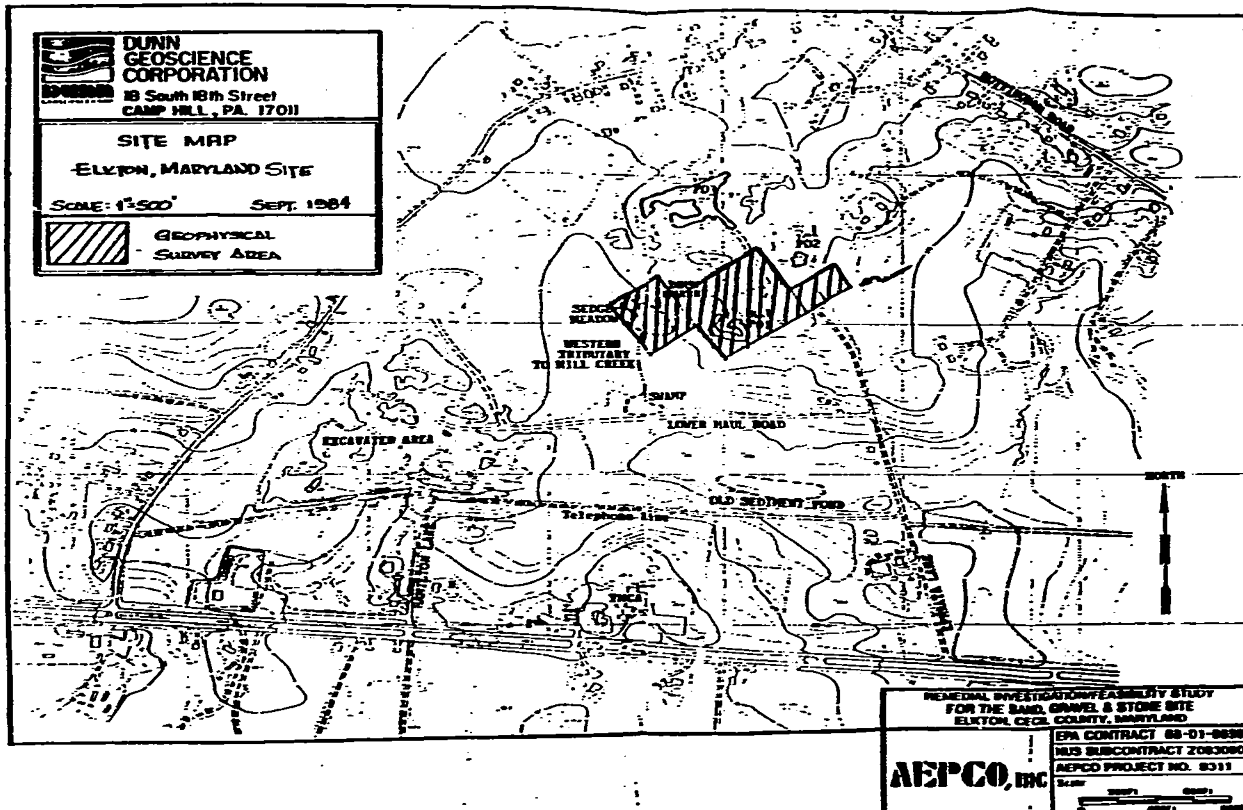
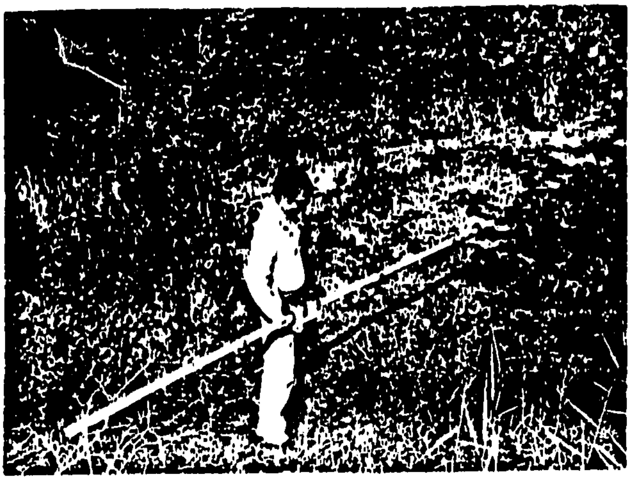
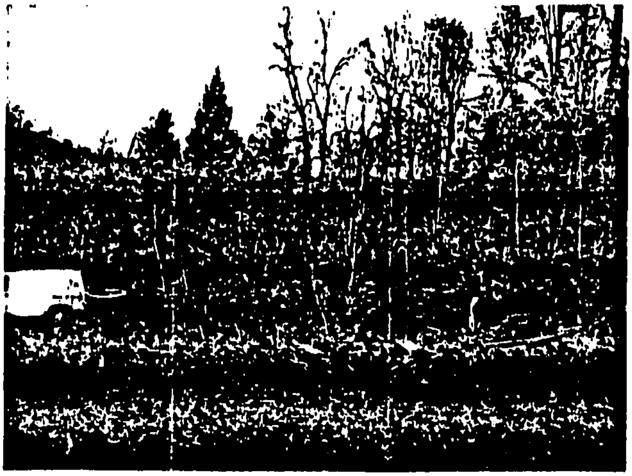

DUNN GEOSCIENCE CORPORATION
18 South 18th Street
CAMP HILL, PA. 17011
SITE MAP
ELKTON, MARYLAND SITE
SCALE: 1"=500'
SEPT. 1984
GEOPHYSICAL SURVEY AREA
SEDGE MEADOW
WESTERN TRIBUTARY TO MILL CREEK
SWAMP
LOWER HAUL ROAD
EXCAVATED AREA
OLD SEDIMENT POND
Telephone line
NORTH
REMEDIAL INVESTIGATION/FEASIBILITY STUDY
FOR THE SAND, GRAVEL & STONE SITE
ELKTON, CECIL COUNTY, MARYLAND
AEPCO, INC
EPA CONTRACT 68-01-6699
NUS SUBCONTRACT 20830802
AEPCO PROJECT NO. 8311

FIGURE 1



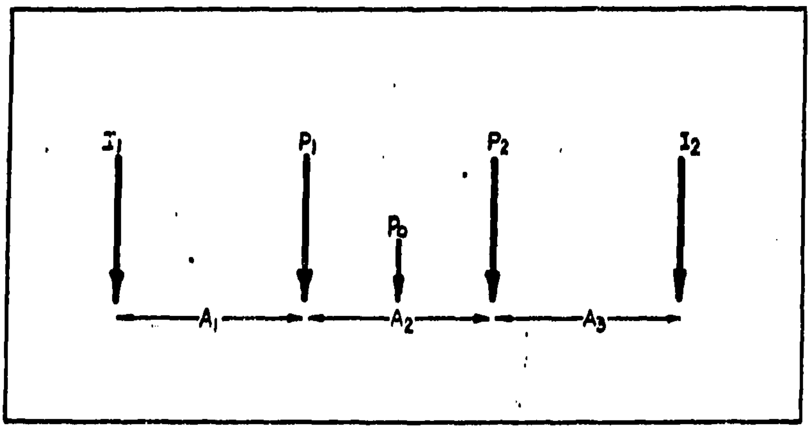
(A) EM-31



(B) EM-34

FIGURE 2 TERRAIN CONDUCTIVITY METERS EM-31 & EM-34 IN USE

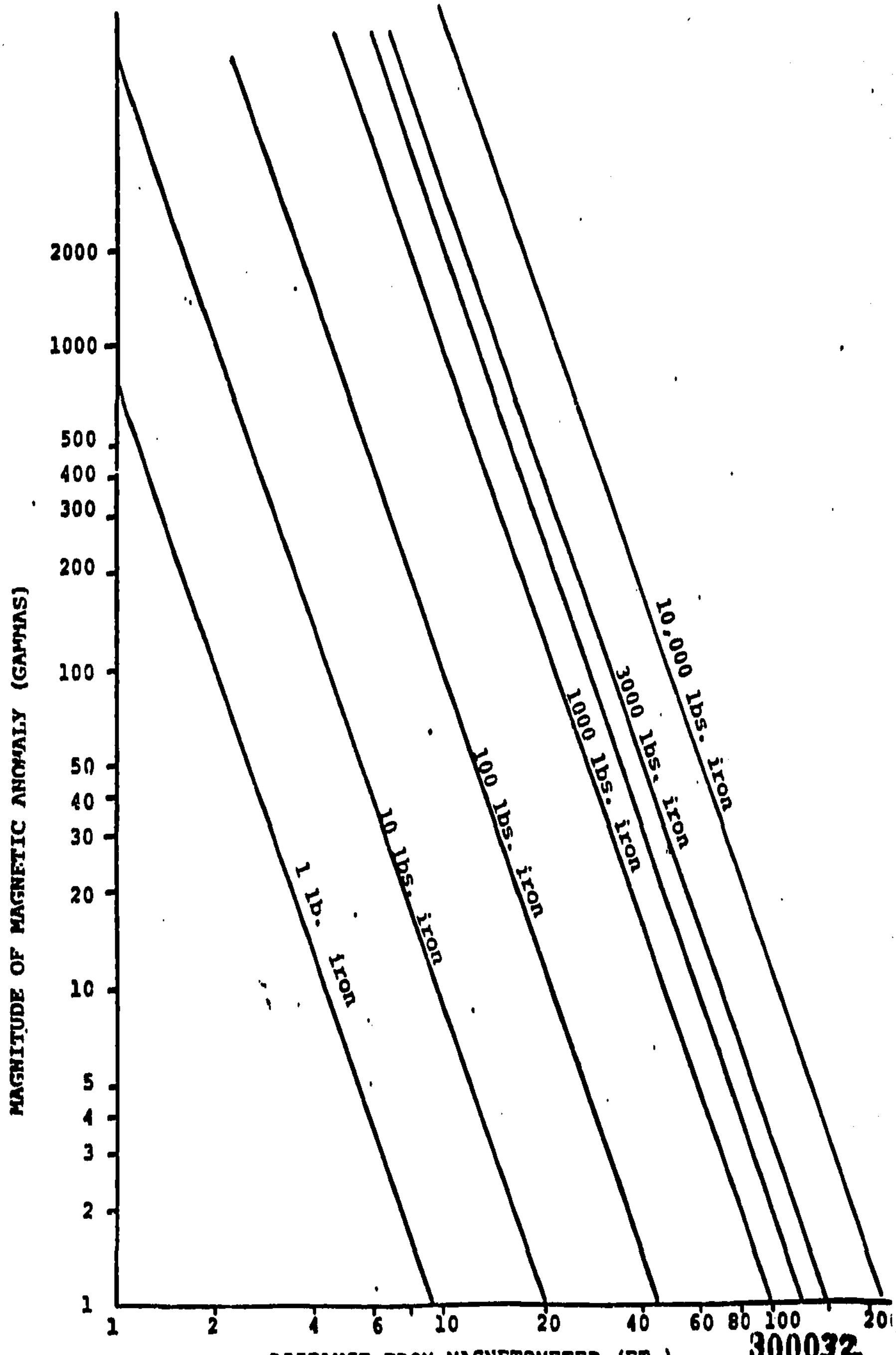
300030



I_1 and I_2 = Current Electrodes
P_1 and P_2 = Potential Electrodes
P_O = Lee Center Electrode
$A_1=A_2=A_3$ = Spacing Between Adjacent Electrodes

FIGURE 3 SCHEMATIC DIAGRAM OF WENNER ARRAY WITH LEE MODIFICATION

300031

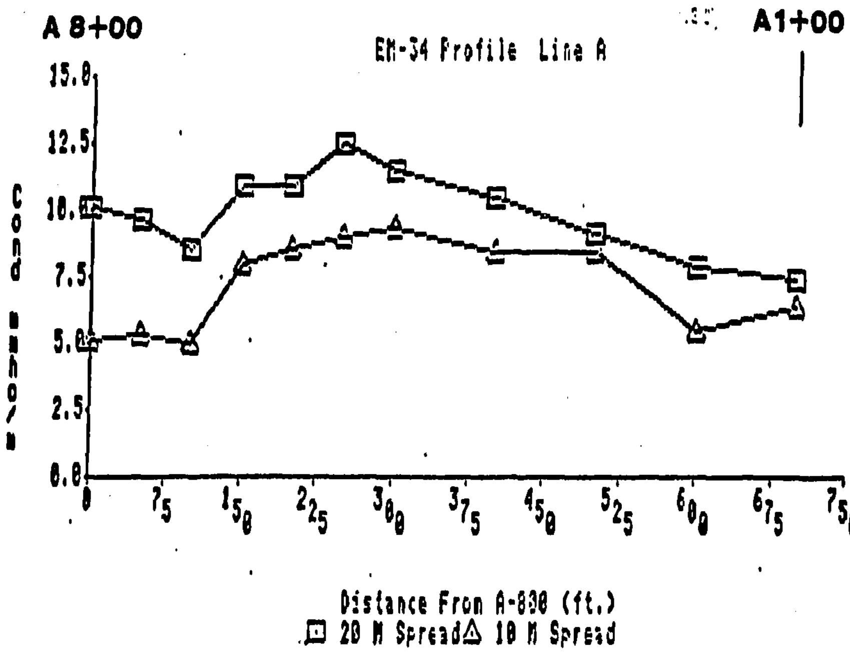


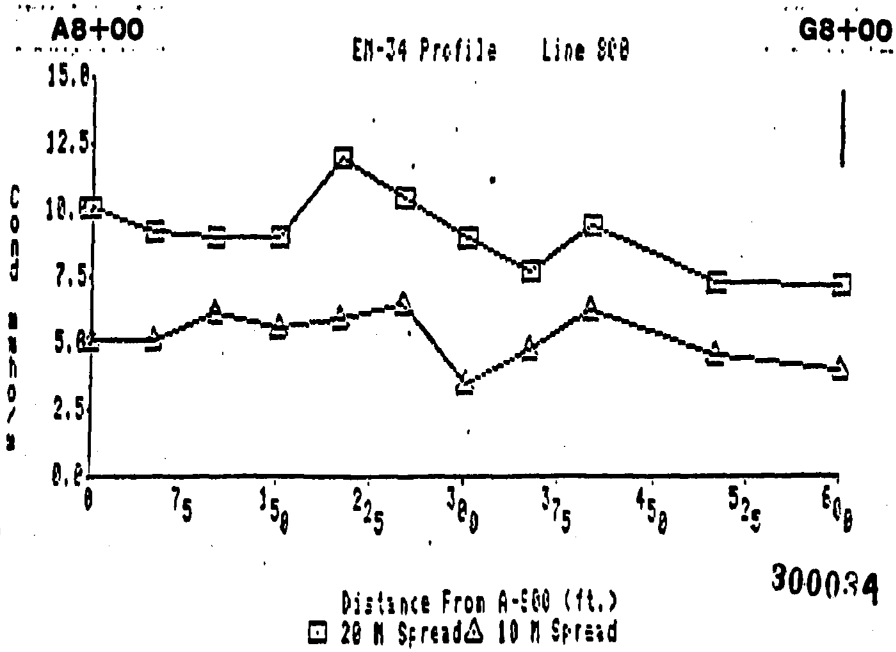
300032

Figure 4 Nomogram for estimating anomalies from typical objects (k=8 cgs) (after Breiner, 1973).

APPENDIX A

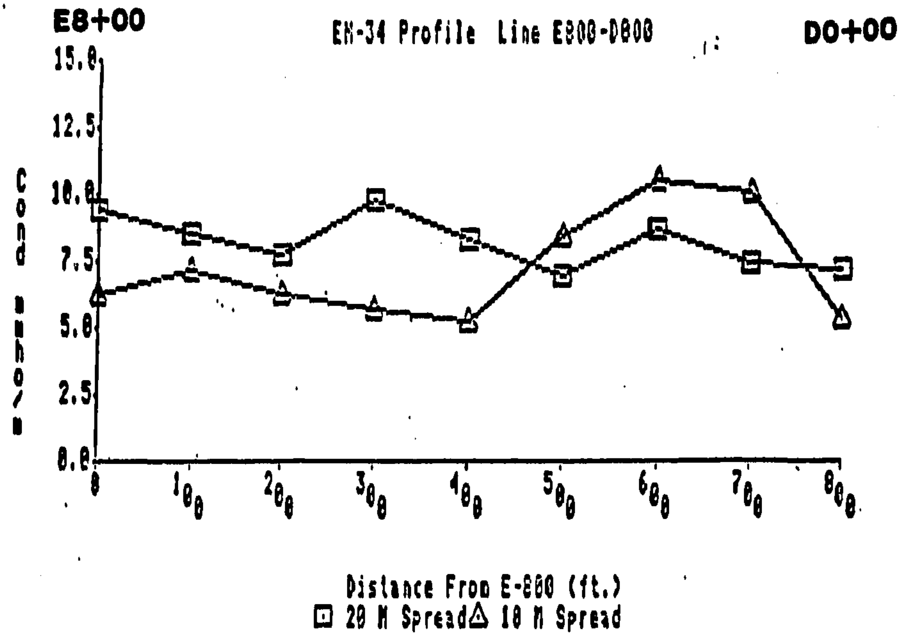
EM-34 DATA PROFILES

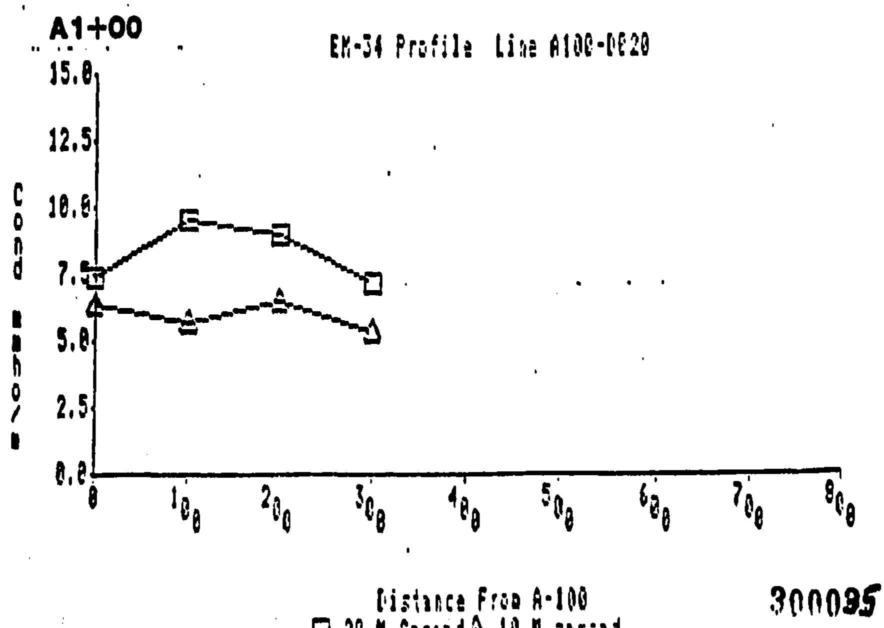




300034

DUNN GEOSCIENCE CORPORATION





300095

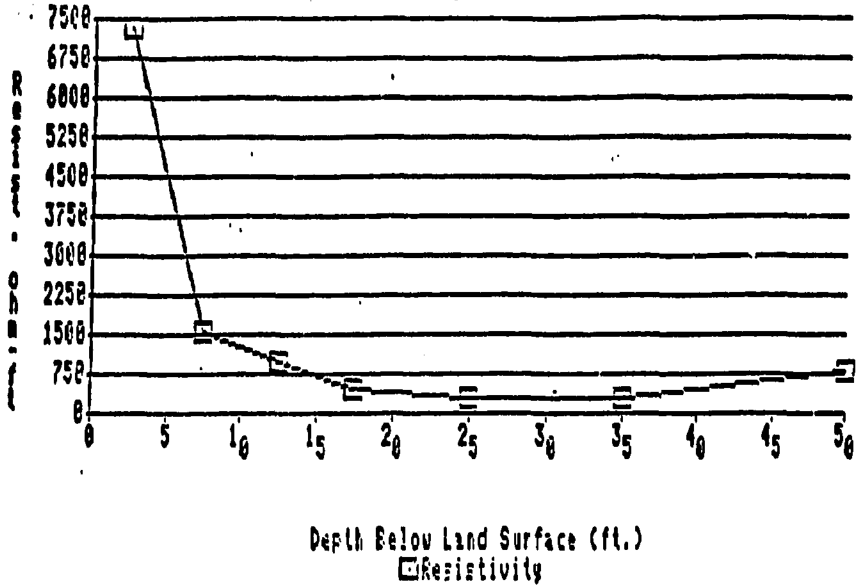
DUNN GEOSCIENCE CORPORATION

APPENDIX B

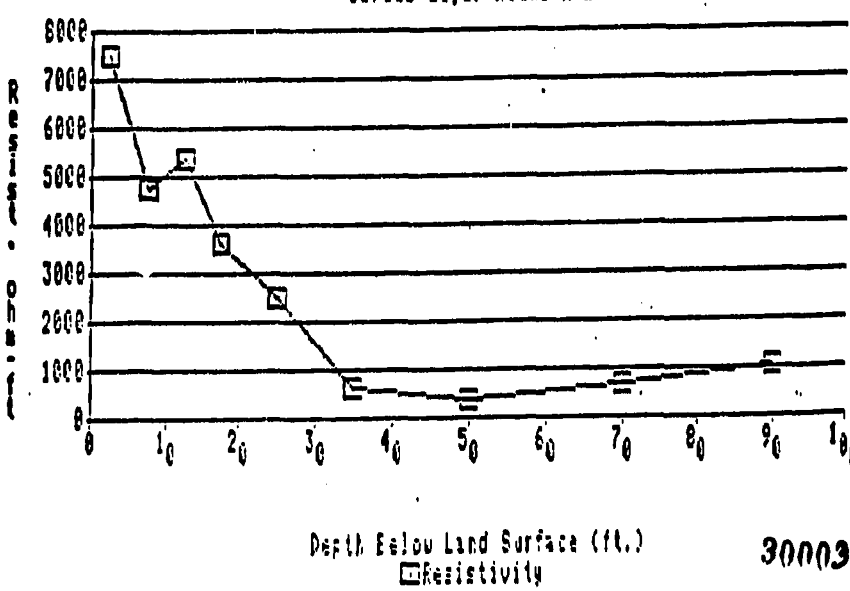
RESISTIVITY PROFILES

300036

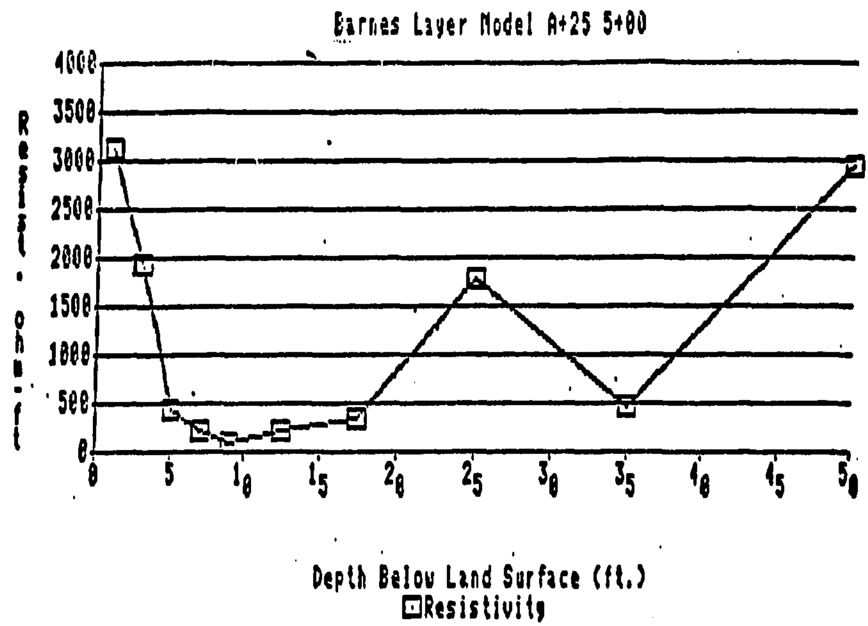
Barnes Layer Model A 1+00

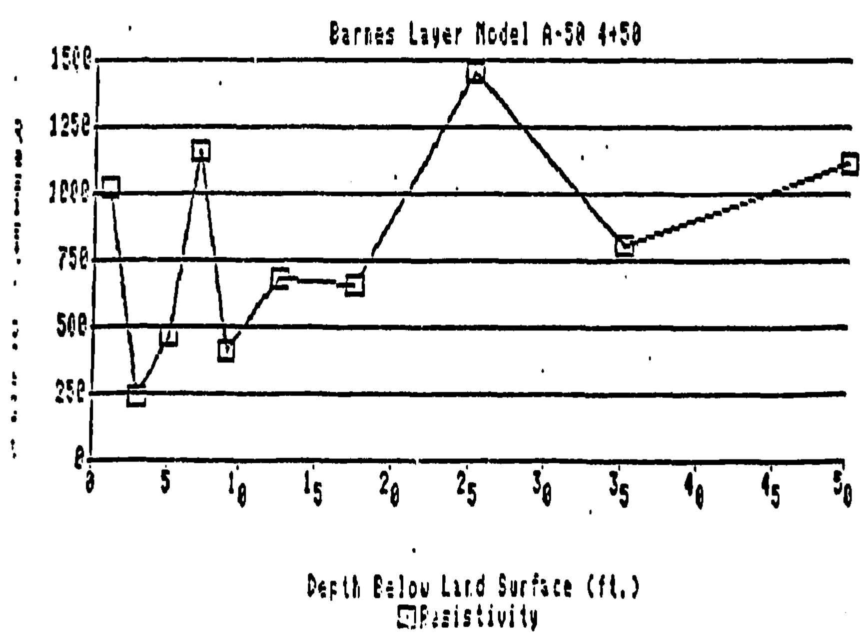


Barnes Layer Model A 2+25



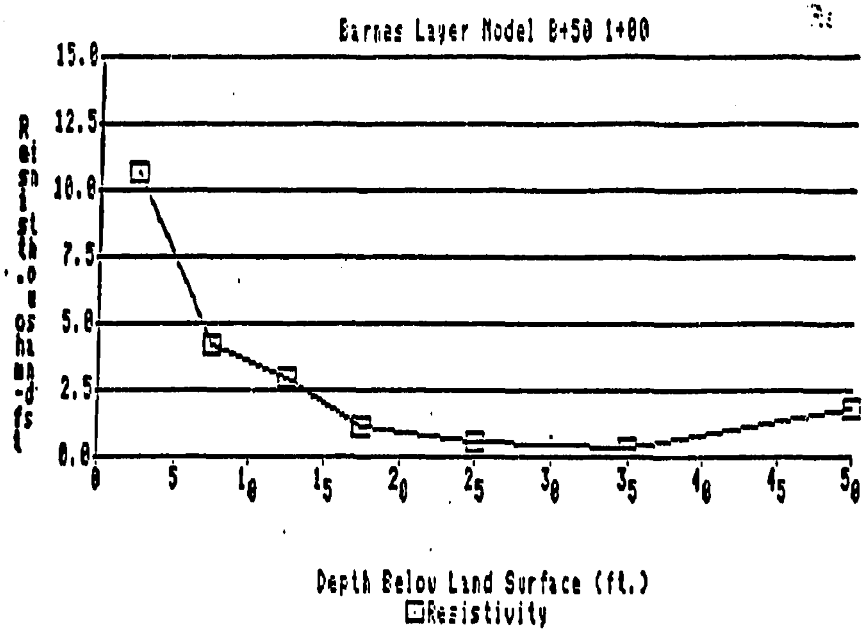
300037

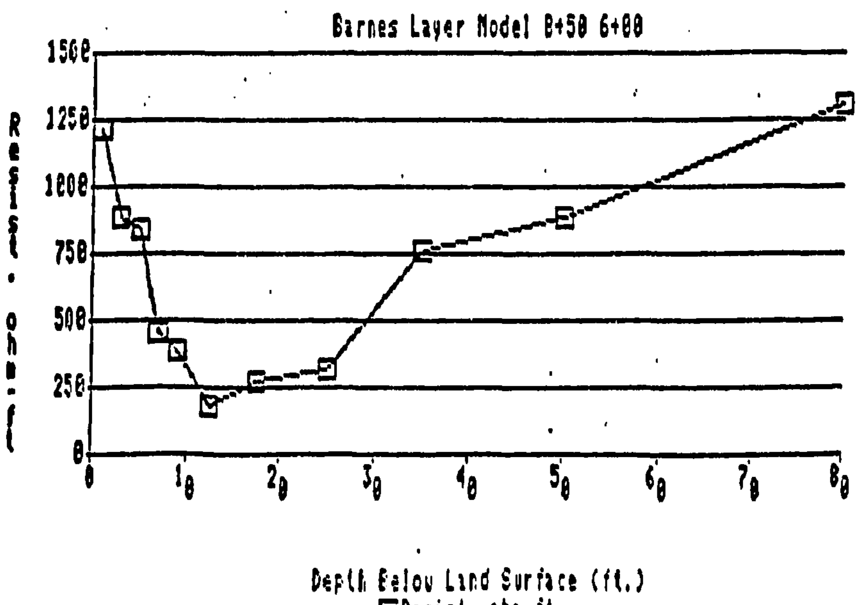




300038

DUNN GEOSCIENCE CORPORATION

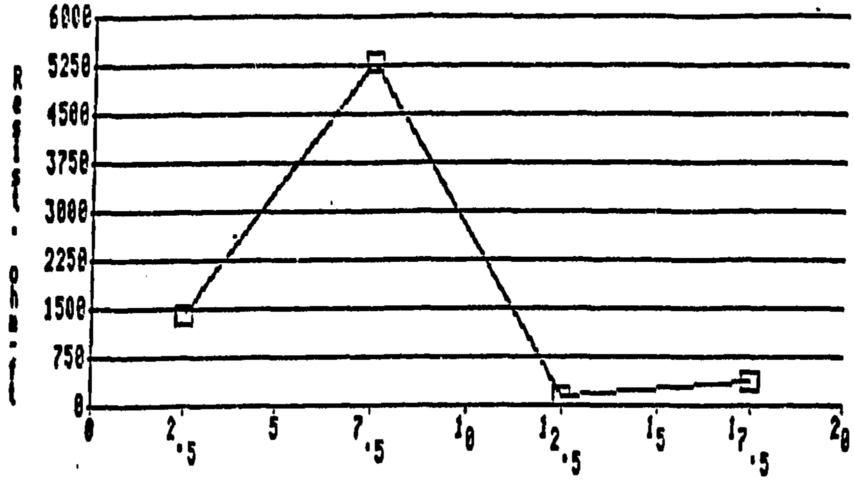




300039

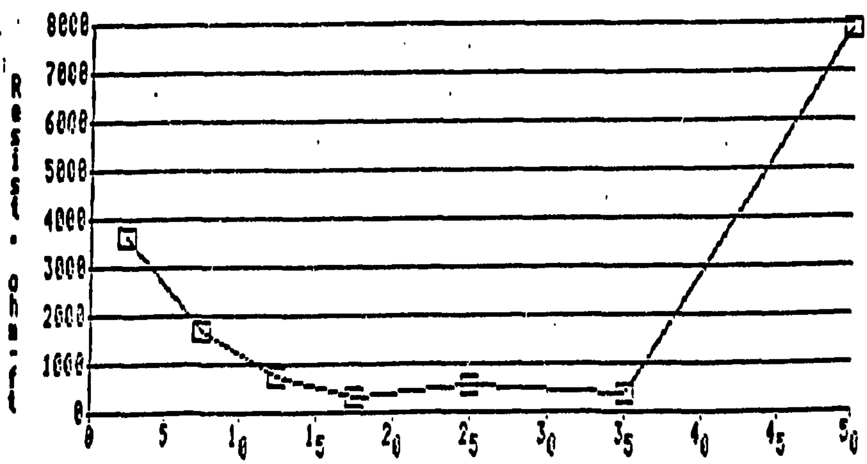
DUNN GEOSCIENCE CORPORATION

Barnes Layer Model D 1+00



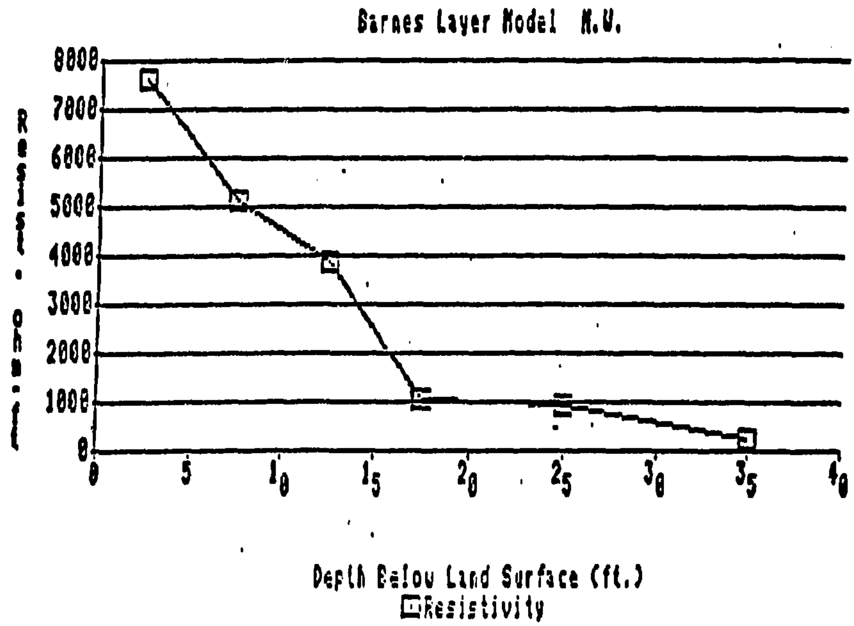
Depth Below Land Surface (ft.)
Resistivity

Barnes Layer Model D+50 4+25



Depth Below Land Surface (ft.)
Resistivity

300040


Barnes Layer Model N.U.
Resist. Ohm-ft
8000
7000
6000
5000
4000
3000
2000
1000
0
0
5
10
15
20
25
30
35
40
Depth Below Land Surface (ft.)
Resistivity

300041

APPENDIX C

MAGNETIC DATA

(to be included in the final report)

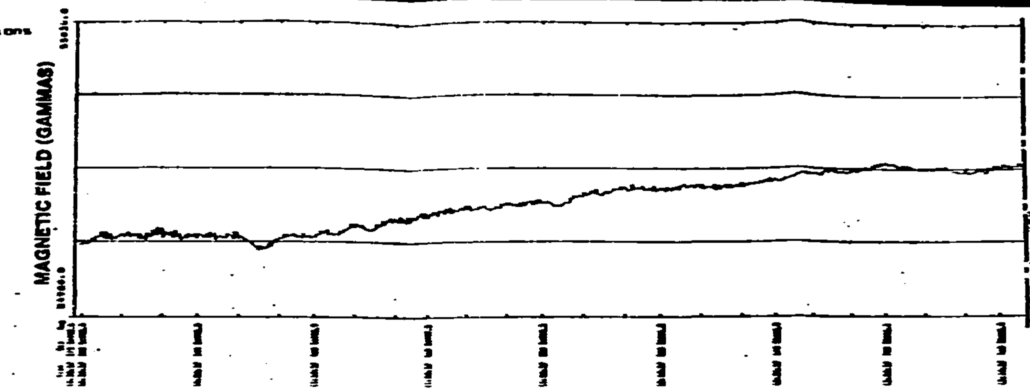
APPENDIX D

MAGNETOMETER BASE STATION PROFILE

300043

Base Station Diurnal Fluctuations

Data file [illegible] has [illegible] records.
Magnetic data HIGH is [illegible].
Magnetic data LOW is [illegible].
Full scale deflection is 30.0 gammas.



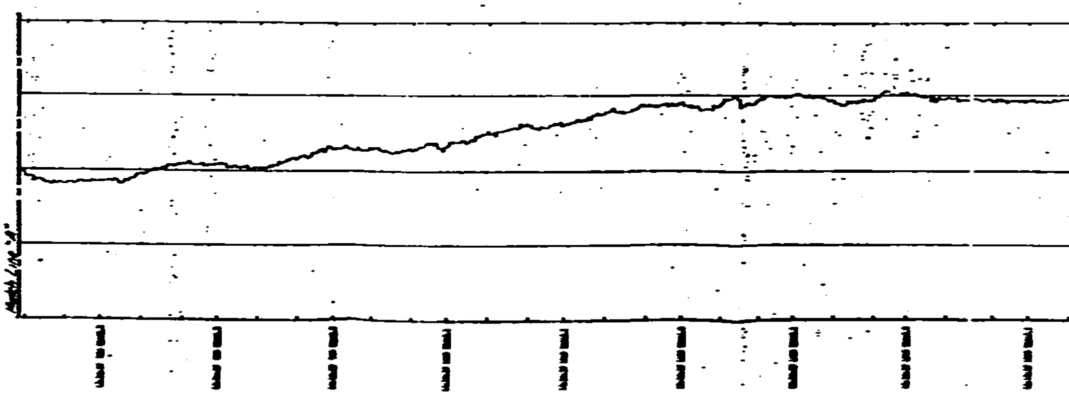


EXHIBIT I

ISO-CONDUCTIVITY CONTOUR MAP

DUNN GEOSCIENCE CORPORATION

300045

EXHIBIT 1

300046

EXHIBIT III

ISO-MAGNETIC CONTOUR MAP

DUNN GEOSCIENCE CORPORATION

300047

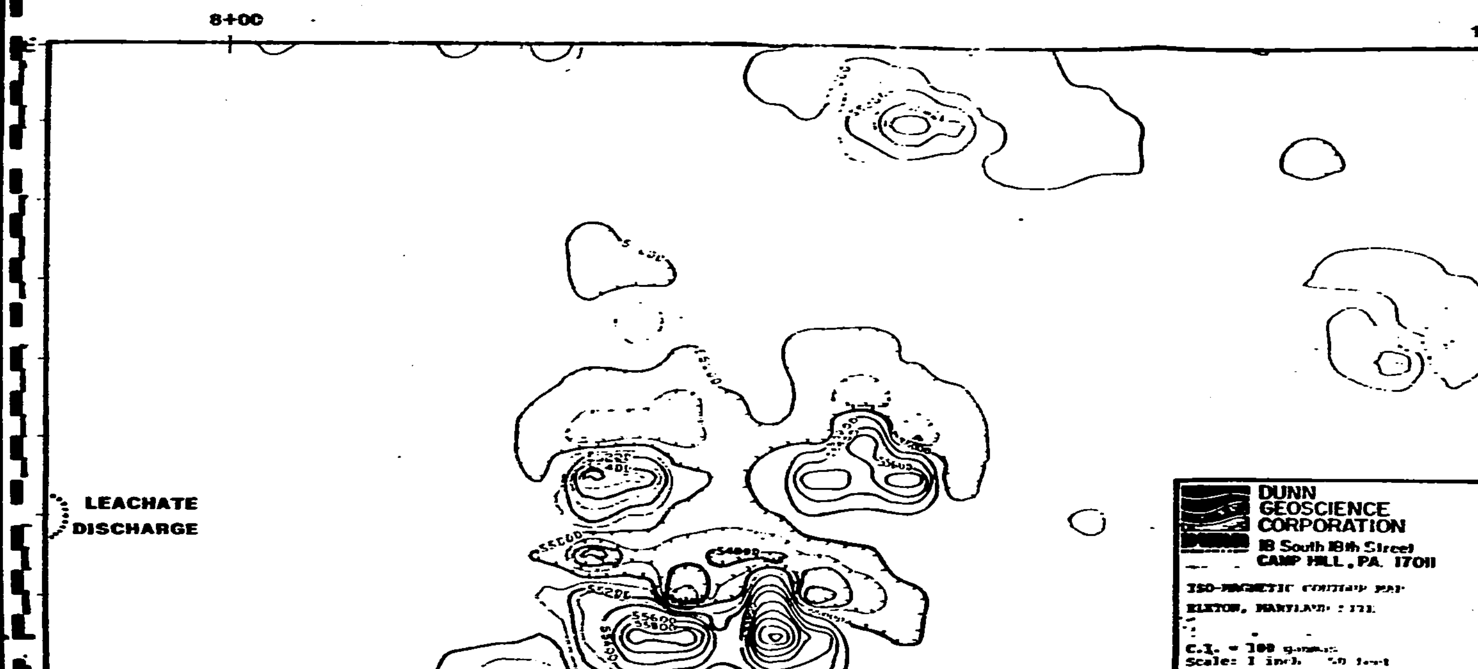


EXHIBIT III

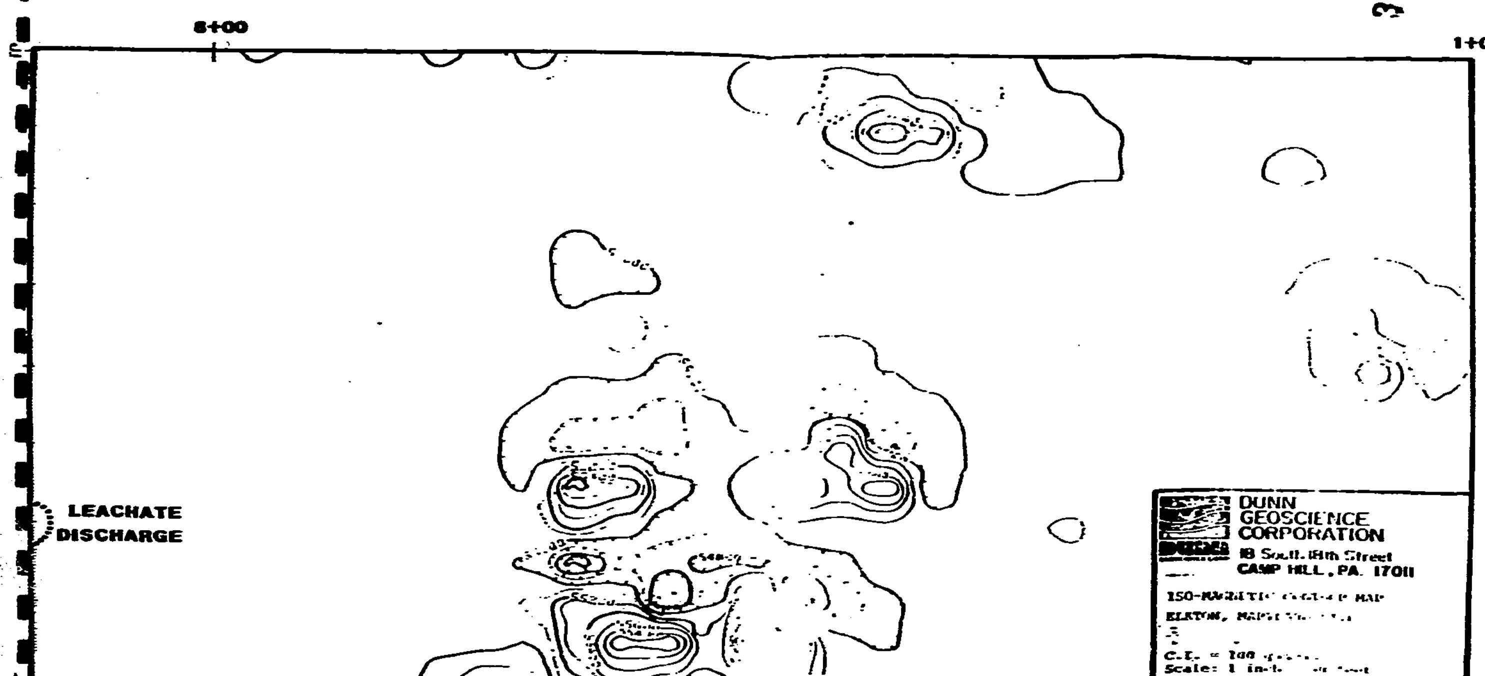
300048

EXHIBIT IV

ISO-MAGNETIC PERSPECTIVE MAP

DUNN GEOSCIENCE CORPORATION

300049

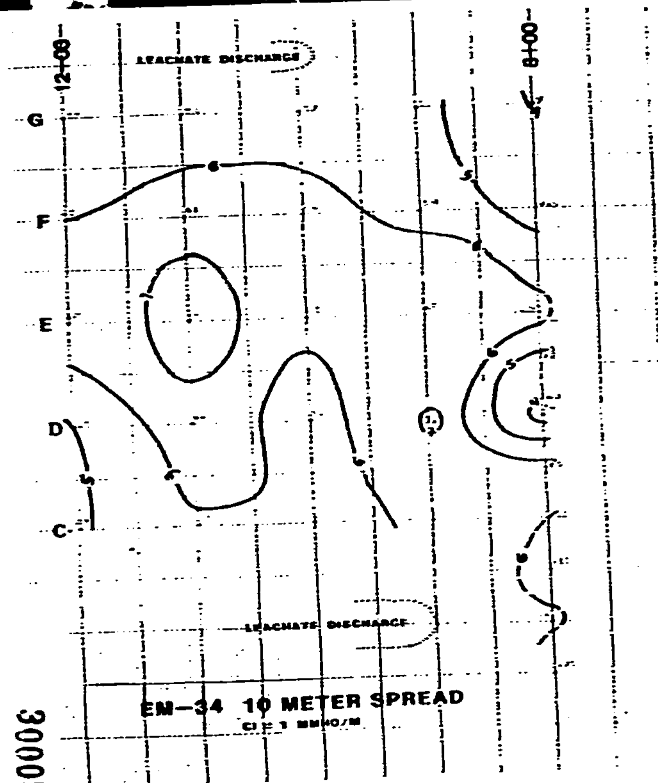


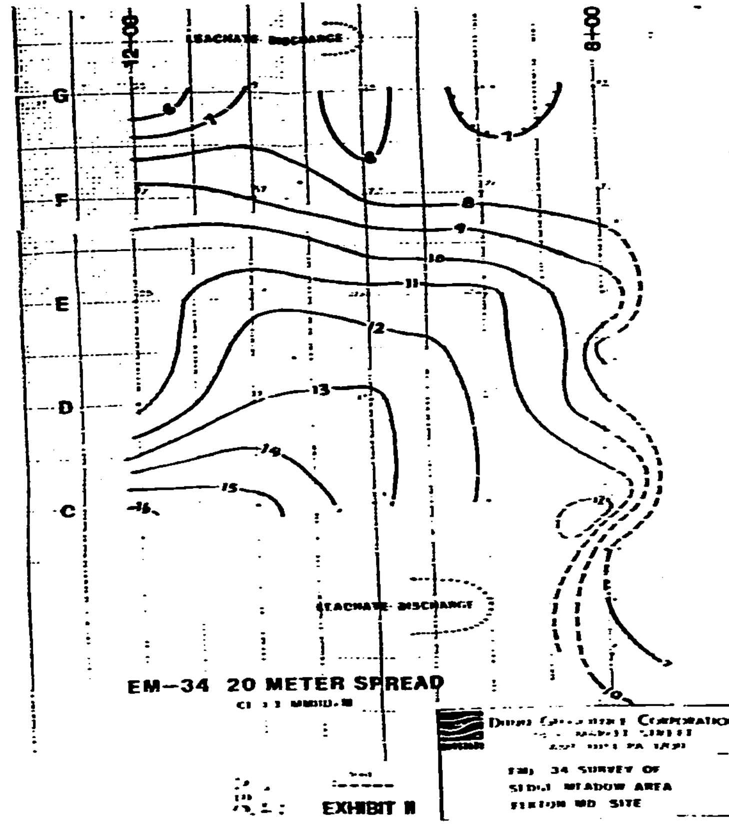
DUNN
GEOSCIENCE
CORPORATION
18 South 18th Street
CAMP HILL, PA. 17011

ISO-MAGNETIC [illegible] MAP
ELKTON, MARYLAND [illegible]

C.I. = 100 [illegible]
Scale: 1 inch [illegible] feet

EXHIBIT III


12+00
8+00
G
F
E
D
C
LEACHATE DISCHARGE
LEACHATE DISCHARGE
EM-34 10 METER SPREAD


12+00
8+00
G
F
E
D
C
LEACHATE DISCHARGE
LEACHATE DISCHARGE
EM-34 20 METER SPREAD
EXHIBIT II
34 SURVEY OF
MEADOW AREA
SITE